National Aeronautics and Space Administration

PLANETARY PROTECTION ADVISORY COMMITTEE

March 18-19, 2002
NASA Headquarters
Washington, DC

MEETING REPORT

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John D. Rummel	Norine E. Noonan
Executive Secretary	Chair

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters, Washington, DC
March 18-19, 2002

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Meeting Report Prepared By:
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Monday, March 18

Welcome, Introductions, and Charge to the Committee
Dr. Norine Noonan, Chair of PPAC, called the meeting to order and welcomed committee members, liaisons from other Federal agencies, representatives from international space agencies, and other meeting attendees. After introductions and logistical information, Dr. John Rummel, Executive Secretary, reviewed the charge to PPAC. The PPAC has been established under the auspices of the NASA Advisory Council (NAC) and reports directly to the Associate Administrator for Space Science, and through the Council to the Administrator. It has been charged to focus on policy, implementation, and organization for planetary protection, including forward contamination and back contamination. In addition to the 15 to 20 formal members, there are nonvoting representatives from other Government agencies as well as nonvoting liaison representatives from other national and international organizations. Key decision areas for advice include forward contamination/spacecraft bioload (e.g., Europa requirements, spacecraft preparation) and back contamination/sample containment and hazard analysis (e.g., policy and approach, and biohazard protocol). In response to a question, Dr. Rummel noted that other agencies will consult with NASA on launch licenses.

Report from the NASA Advisory Council
Dr. Noonan briefly reviewed the origin and history of PPAC, which grew out of a Task Force on Planetary Protection under the Space Science Advisory Committee (SScAC). It was not made a Subcommittee of the SScAC due to a potential or perceived conflict of interest. All of the standing advisory committees of NASA, including PPAC, have a seat at the NAC. The NAC provides advice to the Administrator, and issues concerning planetary protection will be of great importance. It provides a way for people who are not scientists or technologists to have some significant input. Dr. Noonan noted that the last three meetings of the NAC have focused on the International Space Station (ISS). Dr. Zoloth added that the chosen Space Station mission is the human exploration and development of space, and this would be relevant to PPAC. The next NAC meeting is in June, and Dr. Noonan will provide a report from PPAC at that meeting. Dr. Noonan asked the current members to consider other people, skills, and disciplines that would be appropriate to add to the Committee roster, e.g., science communication. Dr. Noonan emphasized the importance of completing the committee paperwork and thanked the members for their service. In response to a question, Dr. Noonan indicated that the product of the meeting will be a letter to Dr. Edward Weiler, Associate Administrator for Space Science, which includes an expression of concerns, a summary of recommendations, and issues for the next meeting. Although the Committee reports to Dr. Weiler, the real beneficiary of its advice on a day-to-day basis is Dr. Rummel, who is the designated Agency Planetary Protection Officer (PPO). In addition to NASA missions, PPAC will look at missions in which NASA participates, e.g., the Mu Space Engineering Satellite (MUSES)-C. Dr. Noonan, Dr. Zoloth, and Dr. Atlas discussed the similarities of PPAC to the Recombinant Advisory Committee (RAC) in terms of a broader representation of society and the concerns surrounding early activities. In response to comments, Dr. Rummel indicated that NASA will make the minutes of PPAC meetings accessible on a Planetary Protection web site.

Introduction to Planetary Protection
Dr. Rummel provided a brief introduction to planetary protection and the history of planetary protection principles and policy. Quarantine standards were adopted by the International Council of Scientific Unions (ICSU) in 1958. The National Academy of Sciences (NAS) made specific recommendations for the practice of planetary quarantine in their 1958-1960 studies; and by the early 1970's, NASA had reached a robust state of capability in both policy and practice. NASA's policy is to preserve planetary conditions for future biological and organic constituent exploration (avoid "forward" contamination) and to protect the Earth and its biosphere from potential extraterrestrial sources of contamination (avoid "backward" contamination). Most of what we know about the potential for life in the solar system has been learned since the US Viking missions which landed on Mars in 1970. Earth organisms live in extreme environments previously thought impossible. There is the potential for present-day water on the Mars

surface and abundant water in the past. There is a potential ocean on Europa. Non-space issues raise public awareness, e.g., biotechnology, medicine, the environment, and biodefense. Dr. Rummel showed the known locations of past, current, and planned interplanetary vectors and return sites. The Committee on Space Research (COSPAR) is the international arm that is concerned with planetary protection. COSPAR maintains a Planetary Protection Policy, and its policy development capabilities are being clarified and intensified. The COSPAR policy is very similar to NASA's. Dr. Rummel briefly reviewed the charter of COSPAR's Planetary Protection Panel and noted that he is the Chair of this Panel at the present time. An international workshop is planned for April 1-4, 2002, in Williamsburg, Virginia. Dr. Rummel showed the Planetary Protection Mission Categories under the COSPAR policy. A Category I mission is not of direct interest for understanding the process of chemical evolution and no protection of such planets is warranted, e.g., the Near Earth Asteroid Rendezvous (NEAR) mission. Dr. Zoloth noted that there may be reasons of concern other than biological contamination. Category II represents bodies that are of significant interest, but only a remote chance that contamination by a spacecraft could jeopardize future exploration, e.g., Voyager. Category III missions are those of significant interest and/or the origin of life and which provide a significant chance of contamination which could jeopardize a future biological experiment, e.g., fly-bys and orbiter missions to Mars. Category IV missions have the same priorities as Category III, but are landed or probe missions. Any sample return mission from any solar system body is a Category V. Category V missions can be "unrestricted" or "restricted" return. In response to questions, Dr. Rummel noted that the term "biological contamination" is intended to cover issues pertaining to evolution and the origin of life. Policy is based on the most current scientific advice. Each mission is examined carefully. Requirements can be specially tailored to specific missions. Scientific results of planetary missions are provided to the PPO. In response to a comment, Dr. Rummel indicated that he would provide documents that would clarify some of the "definitions" used in planetary protection under the current framework. However, not all terms are specifically defined in the documents. Dr. Noonan observed that the state of the science (what we know) leads to a weight-of-evidence approach based on a framework. In the future, what we learn (a change in the state of the science) may lead us to reconsider what we do. The Committee discussed the degree to which it should look at benefits versus risk. Dr. Rummel highlighted NASA's policy documents, the PPO responsibilities, and planetary protection mission constraints. Mission constraints depend on the nature of the mission, the target planet, and current knowledge. He also noted the recent (1992 – 2001) planetary protection studies by the National Research Council (NRC)/Space Studies Board (SSB) and indicated that these reports would be made available to Committee members.

NASA's Solar System Exploration Program

Dr. Colleen Hartman, Director of the Solar System Exploration (SSE) Division in the Office of Space Science, provided an overview of the SSE Program. She summarized some key recent results from NEAR (Eros), Galileo (Ganymede and Europa), Cassini (the current flagship mission of SSE), and Deep Space (DS)-1 (validation of 12 technologies and observations of Comet Borrelly). Upcoming missions include Stardust (to collect comet dust) and Genesis (to return solar wind materials). Comet Nucleus Tour (CONTOUR) is the next SSE launch (July 2002). It will have multiple comet encounters. Deep Impact shoots a projectile into Comet Temple 1. Messenger flies by Venus and encounters Mercury in 2009. Dr. Hartman reviewed the FY 03 President's Budget. The White House gave an "effective" rating to only two NASA research and development (R&D) programs—Discovery and Explorer. The Outer Planets Program was rated "ineffective," and funding was not continued. One of the major new initiatives is the New Frontiers Program—a competitive line (double the funding cap of Discovery missions) for solar system exploration. NASA will wait for the NRC Decadal Survey results and then will compete one to three missions. Dr. Kerridge noted that in 1993, COMPLEX prioritized targets for the 1995 – 2010 timeframe. The current Decadal Survey will prioritize missions. For New Frontiers, the funding supports one launch every 3 or 4 years. The other new initiative for SSE was the Nuclear Systems Initiative (NSI). It has three parts: 1) a development program for an improved radioisotope power system (RPS); 2) an R&D program for nuclear electric power; and 3) an R&D program for nuclear electric propulsion. NASA has no capability to handle any radioactive sources; those sources are owned and controlled by the Department of Energy (DOE). Dr. Hartman described the radioactive source (plutonium) used for all radioisotope power systems and how the advanced RPS units will be used. An RPS unit will survive all credible launch failure scenarios. When the plutonium is in pellet form, it is non-hazardous; it is hazardous when powderized and inhaled. Russian fuel will be purchased for the RPS program. Nuclear electric propulsion will enable

entire new classes of missions. The R&D program for nuclear reactors will examine several technology options. In 5 years (FY03 – FY07), the President's Budget is $940 million for all three parts of the NSI. The SSE Division will create a NSI Science Definition Team that will include both scientists and technologists. Dr. Noonan noted that the NSI enables missions (including return missions) to planets that couldn't have been contemplated before. This should concern this Committee and bears watching. Dr. Hartman briefly reviewed the other aspects of the FY 03 President's Budget and the "fever" chart that depicted project status of SSE missions. Two missions are "red"—Rosetta (overrunning) and Pluto Kuiper Belt (no funding identified after FY02). Two missions were selected under the Discovery 9 and 10 selection process—Dawn and Kepler (delayed start to FY03). In-Space Propulsion started in FY02. It looks at other ways to reduce power and propulsion, e.g., aerocapture, next generation ion thruster, and solar sails. Overall, SSE did very well in the FY 03 budget process. The President's FY03 Budget increased planetary missions by 73% and all planetary activity by 88%.

NASA's Mars Exploration Program

Mr. Orlando Figueroa, Director for Mars Exploration, provided an overview of the strategy for exploration of Mars. A key question is whether life ever arose on Mars. The strategy is "follow the water," and the approach is "seek—in situ—sample." The four objectives in the science strategy are to understand the potential for life elsewhere in the universe, characterize the present and past climate processes, understand the geological processes, and develop knowledge and technology necessary for sample return. Currently, the Program is focusing on "seeking" and creating a foundation of where to go. Mr. Figueroa summarized what we have learned to date from Viking, Mariner, Mars Pathfinder, and Mars Global Surveyor. The next stage is to refine the number of hundreds of promising sites to two for in situ validation. Mr. Figueroa showed what the Program looks like (by launch year), following this strategy. The FY03 budget supports the outlined program through 2009, including a robust R&A program and a technology program with two components—base technology (broad applicability with particular emphasis on instrument technology) and focused technology (technologies that feed specific missions in the mid-term timeframe). In response to a question about sample return, Mr. Figueroa indicated that the President's budget does not include investment in any opportunities after 2009; it requests NASA propose options for sample return after 2009. This option-driven program has two components: (1) what is expected to be learned this decade (2) the issue of affordability. In response to a question, Mr. Figureroa noted that about $10 million per year will be devoted to instrument technology. In addition to in-situ instrumentation, significant investment will also be needed for incremental sample return. Mr. Levy noted that in-situ instrumentation has been under-emphasized in NASA in the past, and he encouraged the Program to invest in this technology area. Mr. Figueroa discussed the next steps in Mars exploration. The 2001 Mars Odyssey will map the mineralogy, morphology, and elemental composition of the surface and measure the near-space radiation environment. The Twin Rovers in 2003 will learn about the climate on Mars and scout for regions where mineralogical evidence of water has been found. The Mars Reconnaissance Orbiter (MRO) will provide higher resolution reconnaissance. The 2007 competed Scout missions will provide an opportunity for innovations in science, measurement systems, and mission concepts. An area of concern is the cost ceiling ($325 million per Scout mission) and some of the studies show that about a third of the missions would be outside the cap. In response to a question, Mr. Figueroa stated that the core program is geared very heavily toward the life question. Over the last few years, the Mars Exploration Program Analysis Group (MEPAG) has focused on the goals and objectives of the program. The Scout program is intended to address the gaps in the core program. The 2009 Mobile Science Laboratory (MSL) will incorporate RPS for long-range, long-duration science. It will demonstrate precision entry, descent, and landing as well as active hazard avoidance. It will also validate rover design and technology for extended operation on the surface. Mars Sample Returns—when and where they fit in the next decade—are still an unanswered question. A challenge for the team is to look at how to compress the time required to define, build, and outfit the quarantine facility for samples. Although human exploration is not part of the agenda at this point, what the MEP is doing will build the foundation for it.

Tuesday, March 19

Discussion with the Associate Administrator

Dr. Edward Weiler, Associate Administrator of the Office of Space Science (OSS) provided an overview on NASA's Space Science Enterprise. He briefly reviewed the NASA and OSS organization and the Enterprise management philosophy. In the past 5 years, the run out peak of the OSS budget has more than doubled. Currently, the OSS budget is expected to be at $4.5 billion by 2007. The science program is organized around four themes: Sun-Earth Connection, Solar System Exploration, Structure and Evolution of the Universe, and Astronomical Search for Origins. Dr. Weiler summarized the basic science questions, current and future programs, and recent science highlights in each of these themes. Space Science is filling the professional journals with good science. In addition, space science is doing very well against the 2001 *Science News* (a popular science magazine) metric (the 100 top discoveries in all fields of science each year). Last year, NASA was 8% of the top discoveries, and space science was about 83% of those. Dr. Weiler showed the major NASA space science launches for CY93 through CY04. The launch rate continues to rise. Dr. Weiler stated that the most important result of NASA's space science program is the sense of wonder and imagination it inspires in America's youth. Dr. Weiler showed the national distribution of the Enterprise education/outreach in 2001. OSS has over 3000 venues for its events. In addition, OSS is "hot linked" on the Department of Education web site. With respect to biological contamination control, the Associate Administrator for Space Science, or his designee (the PPO), is responsible for the overall administration of NASA's planetary protection policy. This includes maintaining the required activities in support of the planetary protection policy at NASA Headquarters, assuring that the research and technology activities required to implement the planetary protection policy are conducted, and monitoring space flight missions as necessary to meet the requirements for planetary protection certification. Since this will be a much more active area in the future, PPAC was established.

In response to a question, Mr. Weiler agreed that the interest in Europa is high since the prospect for water on Europa is promising (from the mid-1990's). Two years ago, Mars Global Observer (MGO) found some evidence of possible recent water on Mars. Two years ago, the SSES established a program priority—Pluto—and NASA released an Announcement of Opportunity (AO). However, under the new Administration, there is no funding for Pluto beyond FY02. With respect to human exploration, OSS is doing the preparatory work that will be very valuable for any future human mission. In addition, technologies that are being pursued by OSS (e.g., nuclear power) will be needed by human exploration.

Planetary Protection Advisory Committee's Role

Dr. Rummel discussed PPAC's role in mission requirements, operations, and extensions, interagency coordination, and intergovernmental planning. Under current planetary protection policy, NASA does not provide mission support to an international mission, e.g., MUSES-C, unless NASA policy is followed by that mission. This Committee will examine the issues associated with such a mission and will provide specific advice to OSS. More data on the forward contamination issues will be available in the fall. Dr. Noonan discussed the interagency coordination. Some of the agencies, e.g., USDA, DOT, NIH, have specific regulatory responsibilities with regard to life forms that may or may not be from the Earth. In addition, these agencies have expertise that would be valuable to NASA. A number of agencies have already designated liaisons to this Committee and are taking this activity seriously. NASA will continue to work with agencies that are not yet represented. The former Planetary Protection Task Force named the agencies that should be considered. At that time, DOD was not included, but this Committee could extend an invitation to that organization if it feels it would be appropriate. In response to a question, Dr. Noonan noted that it is possible for a Federal Advisory Committee Act (FACA) committee to put out a call for "public testimony." The PPAC could consider a more public venue and more opportunity for public participation for future meetings.

Introduction to Issues in Returned Sample Handling

Dr. Margaret Race from the SETI Institute discussed issues in returned sample handling. She reviewed the key reports and workshops for sample return planning and Mars Sample Return. She focused on three time periods in history—the Apollo era and subsequent years, the early 1990's, and the past 4 years—and three NRC reports (a 1992 report on forward contamination, a 1997 report on Mars sample handling, and a 1998 report on small bodies). A series of workshops over the past 4 years have led to a draft protocol for sample

return handling. The 1992 NRC report reassessed planetary protection for Mars and concluded that the probability of Earth life growing on Mars was not as likely as previously thought (at the time of Viking). It contained ten recommendations in five categories: bioburden assessment, cleaning and sterilization, science, public engagement, and implementation. The 1997 report looked at Mars Sample Return. The NRC group was charged to assess the potential for returning an extraterrestrial (ET) organism and the large-scale effects from an ET organism on Earth and to recommend research to reduce uncertainty, technical measures to reduce risk, and criteria for distribution of samples. In response to a question, Dr. Rummel noted that the issue of personnel quarantine is not an immediate one but it will need to be addressed. Dr. Orr commented that ownership of the sample is just one issue, and there is a "hodgepodge" of quarantine laws across a variety of agencies. Dr. Zoloth observed that the moral status of an ET life sample would be of interest to ethicists. Dr. Race noted that many issues come into play and have been discussed in the workshops. We are trying to put them into a framework for decision-making. The 1997 NRC report recommended the following: that Mars exploration and study of extremophiles and meteorites continue, that technical measures be taken to reduce risk, and that containment would be necessary until the sample was sterilized or not shown to contain ET life. There were other more detailed recommendations regarding containment, facilities, program oversight, and public involvement. Overall, the NRC group recommended a conservative approach (planetary protection for both planets and science). In response to a question, Dr. Race noted that the handling of samples would be at Biohazard Safety Level (BSL)-4 at a minimum. Samples would be released from containment only if there is no biohazard. The 1998 NRC small bodies committee evaluated the biological potential in samples returned from planetary satellites and small solar system bodies. The committee identified six key parameters to guide deliberations: liquid water, energy sources, organic compounds, temperature, radiation intensity, and natural influx to Earth. It concluded that there are only two alternatives—either strict containment and handling or no special containment beyond scientific needs. In response to a question, Dr. Race noted that each NRC report dealt with life as we know it because there is not enough data on anything else. However, in the recent workshops, there has been more attention on the topic of other-than-carbon-based life, although data is still not available. The report classified samples from certain bodies as I (no special containment) or II (strict containment). Within Classification I, there were two subgroups—those with which we have a high degree of confidence that there is no need for containment, and those with which we have a lesser degree of confidence. There were three other studies related to sample return (the 1999 NRC study on size limits, the 2001 COMPLEX study, and the 2002 NRC study on signs of life), none of which that had the weight of the other major NRC reports. Except for the 2002 report, these reports can be found on the Web site: http://www.nap.edu.

MUSES-C: NASA Participation and the Asteroid

Dr. Donald Yeomans from the Jet Propulsion Laboratory (JPL) introduced the MUSES-C mission. Dr. Fujiwara from Japan's Institute of Space and Astronautical Science (ISAS) reviewed the current status of the mission. MUSES-C is an engineering mission to develop key technologies (ion engine, autonomous navigation, sampling, reentry) requisite for future advance sample return missions. It is scheduled to be launched in November/December 2002 and will arrive near the asteroid 1998SF36 in June 2005. The capsule will return to Earth by high-velocity direct reentry from interplanetary space in June 2007. Dr. Fujiwara described the spacecraft configuration, trajectory and return path, and the sampling sequence. The spacecraft hovers about 10 km above the target surface (the "home" position). From this position, it observes the asteroid surface. After some detailed mapping, the spacecraft descends to the asteroid surface. Sampling is made by shooting small projectiles onto the surface and capturing ejecta in a "touch and go" mode. About eight hours before Earth reentry, the sampling capsule separates from the spacecraft and the capsule descends by parachute through the atmosphere. After landing in Australia, the onboard beacons are active for 2 days. Dr. Fujiwara showed the scientific instruments on the spacecraft and described the sampling device (the most important scientific instrument) in detail. NASA/JPL will be doing ground-based observation of the target asteroid and will provide tracking and navigation assistance by the Deep Space Network (DSN). Ames Research Center (ARC) will test the heat-shield material used for the reentry capsule. Due to the failure of the last launch of the MV rocket, the project was delayed; and the targeted asteroid was changed to the present one. Due to this change, the recovery site will be in the Woomera prohibited area in Australia, and the permitting process is underway. With respect to planetary protection issues, "Environmental Australia" (EA) is in charge. According to the NRC/SSB, S-type asteroids are safe

in terms of planetary protection. However, this policy has not yet been approved by COSPAR or international policy. Action by AE is expected after the COSPAR planetary protection workshop.

Dr. Yeomans discussed the target asteroid and the science rationale. Asteroids represent the leftover bits and pieces from the inner solar system formation process and detailed measurements would identify the chemical mix and conditions from which the inner planets (including Earth) formed. MUSES-C would determine the link between this asteroid's spectral type and its likely meteorite analog. From radar observations, it has been determined that the surface roughness is comparable with asteroid Eros. Dr. Yeomans compared 1998SF36 to other L and LL chondrites. The MUSES-C target body is an S-type asteroid, most likely similar to L or LL chondrites, the most common asteroid type between Mars and Jupiter. The S class is one of several different classes of asteroids. Earth is being inundated by material from S-type asteroids on a daily basis. MUSES-C would also determine the structure, mass, density, and porosity of this asteroid thus allowing better mitigation strategies for potential Earth-threatening objects of this spectral type. Dr. Yeomans stated that with respect to the six key SSB questions on parameters for life, the MUSES-C target asteroid is not an object would require containment because there has been a natural influx (via meteorites) of the type of material equivalent to the sample.

Committee Discussion

The Committee discussed the degree to which the radiation parameter applies to the target asteroid and whether we are looking at a sample material that is the same as natural influx. Dr. Noonan reviewed the framework created by the Academy. The ordinary chondrites are the most abundant material falling on the Earth today. The ordinary chondrites are derived from spectral Type S, and it is reasonable to equate S-type asteroids with ordinary chondritic material. It is highly unlikely that there would be any possibility of life on these bodies. Dr. Orr expressed concern about the criterion related to natural influx. Dr. Noonan clarified that the "equivalent" term in the criterion means spectral or chemical equivalent, not mass equivalent. Dr. Levy observed that although the sample from 1998SF36 will be a surface sample as opposed to the deep interior that is characteristic of the natural influx, and one could argue that there is not absolute equivalence, the surface sample has been exposed to intense radiation and meets the other criterion. Dr. Noonan noted that the SSB recommended that samples falling into Class Ib receive closer scrutiny on a case-by-case basis. If measurements indicate that the target asteroid has features other than expected, the Committee could discuss the containment issue in light of all of the data and make a recommendation. Dr. Robinson posed the question: Will the Committee assessments be made on an ethical as well as a pragmatic basis? If so, what are the criteria? Dr. Zoloth stated that there needs to be the development of an ethical response or an ethical language. Dr. Levy agreed that the deliberations of the Committee will be involved with ethical issues. The Committee discussed the NAS framework that was set out in the 1998 report. Dr. Noonan stated that the Academy framework encompasses the uncertainties for a fairly large class of planetary exploration activities. The MUSES-C mission is before the Committee because U.S. investigators are involved. COSPAR will take up the Academy framework at the Williamsburg workshop. Dr. Rummel noted that the uncertainty embodied in the Ib classification was more scientifically oriented rather than ethically oriented. The six questions were applied to each class of bodies, and that is how the Ib classification was established. With respect to the MUSES-C target, we can answer affirmatively to questions 5 and 6; we don't know enough to answer the other questions. Dr. Kerridge suggested the Committee will inevitably get into ethical issues but that it may not be practical to systematize it. He suggested adopting the framework for scientific issues, and let the ethical issues come up for debate. Dr. Zoloth agreed that the Committee needs to focus on what the scientists think are the troubling issues. Dr. Noonan noted that there is a suite of instruments on board that should provide a wealth of information. If the science team discovers something of concern, there will be a window of time in which discussions on the fate of the spacecraft, and the sample could be initiated and concluded. At this point, the Committee was reasonably comfortable that the target body fell into the category that would not require containment (other than for scientific purposes). However, some of the members were concerned that if something is discovered that would necessitate sample containment, the only options available would be to bring it back or not; there would not be a means of acceptable containment. In response to a question, Dr. Fujiwara indicated that before launch, the sample cone would be cleaned, irradiated, and sealed. Since this is not a life-detection mission, there is not a concern with forward contamination.

The Committee discussed the wording of a proposed draft recommendation regarding planetary protection for the MUSES-C mission. This recommendation was finalized later in the day.

Mars Planetary Protection: Issues and Status

Dr. Rummel discussed the issues associated with Mars planetary protection. The focus of NASA's planetary protection program is to preserve biological and organic conditions for future exploration and protect the Earth from potential extraterrestrial contamination. With respect to international agreements in this area, there is the UN Space Treaty of 1967. In terms of implementation, the UN has consultations with two nongovernmental organizations (NGO's): the International Astronautical Federation and ICSU's subordinate body, COSPAR. COSPAR is the only body that has developed its own planetary protection policy, and it consults with the UN on whether the protection policy is being followed. There is no treaty commitment beyond Article IX of the UN Space Treaty. In the mid-1970's, Viking orbiter images expanded the view of Mars as a planet with a much different and perhaps watery past. The Viking missions landed in 1976. Viking discovered water vapor in the atmosphere, determined polar ice caps are carbon dioxide and water, found the landing site surface to be highly-oxidized, iron-rich clay, and found highly reactive soil chemistry. The spacecraft underwent sterilization. The majority of the Viking Biology Team did not think that life had been discovered on Mars. Since the Viking missions, we have found that Earth organisms live in extreme environments previously thought impossible. The Mars strategy first looks at geology and climate before searching for life. Preparing for human exploration can only be done after we answer the question of life on Mars. In 1992, the SSB released recommendations on forward contamination of Mars. Mars contamination was felt to be much less likely by this Committee. It strongly recommended that a sequence of unpiloted missions to Mars be undertaken well in advance of a piloted mission. Mars Pathfinder successfully demonstrated surface mobility and a robust entry and landing system. ALH84001 suggested that Mars was much warmer and wetter than it is today. Mars Odyssey is currently mapping the mineralogy and morphology of the surface. It will map the elemental composition of the surface and determine the abundance of hydrogen in the shallow subsurface. It will also measure the near-space radiation environment. The 2003 twin Mars Exploration Rovers will learn about the climate on Mars and scout for regions where evidence of water has been found. The MEP is currently in negotiation on planetary protection provisions for the future. In the 2007 timeframe (Scouts), there will be opportunity for PPAC to address forward and backward contamination issues. The cleanliness standard for Viking pre-sterilization is what we use today. There has been a lot of attention on sample return. Dr. Rummel provided a copy of a protocol for Mars Sample Return. The overall issues associated with Mars Sample Return (from the 1997 report) were sample containment and controlled distribution. Dr. Rummel described a direct-entry concept for Mars sample handling. The issues associated with sample collection, containment, and retrieval are compliance with the National Environmental Policy Act (NEPA), location for facilities, who will do the work, and how big the facility will be. The expectation is that Mars organisms will be a distinct possibility and the sample will be contained as if it contains Mars organisms. Dr. Rummel referred to the document, *Quarantine and Certification of Martian Samples*, which addressed the protocol for detection of life and biohazards and the strategy for quarantine and distribution of samples. COMPLEX recommended that all samples in the initial collection return from Mars should be placed in a Quarantine Facility in the U.S. The most important recommendation was that the Quarantine Facility be started at least 7 years in advance of the anticipated return of Mars samples. A series of workshops were planned to develop a draft protocol for sample hazard analysis and release of the sample from containment. A senior-level oversight and review group was chosen to advise the organizing committee on the planning, organization, participants, and conduct of the workshops. There were over 100 workshop participants. Dr. Rummel highlighted the membership of the oversight and review committee and discussed the assumptions for sample hazard analysis. The first samples would return to Earth no earlier than 2011. A number of questions were generated for the Protocol Development Workshops. The Workshops were finished in June 2001 and the output (what the protocol should be) was reviewed by the oversight and review committee. Dr. Rummel asked PPAC to review and endorse the document. After endorsement by PPAC and NAC, the report will be disseminated to relevant audiences and agencies. Dr. Noonan observed that for "rule-making" documents, the normal procedure is publication in the Federal Register for public comment prior to finalization/implementation. Dr. Rummel noted that this was discussed by the committee and would be the right thing to do. However, at this point, the studies that would provide more information on implementation have not yet been conducted. The PPAC should provide advice on how the document

should be disseminated and at what point in the iterative process the document should be published in the Federal Register, given the current status of the Mars Sample Return mission.

The public comments on the document will be useful for formulation of NASA policy and future planning. In response to a question, Dr. Rummel indicated that the protocol talks about eventualities in the event life is found in the samples.

Dr. Noonan asked PPAC to review the document and provide feedback to Dr. Rummel by April 22 regarding any questions or concerns with the document and any thoughts or suggestions on the next steps in the process. At the next meeting, PPAC will devote some time to this topic as well as how to proceed. She noted that the background materials (the workshop summaries) could be made available to the members upon request.

Before the next presentation, PPAC finalized the recommendation regarding the MUSES C mission:

> **The Committee heard presentations on the MUSES-C mission and on the nature of the MUSES-C target body, 1998 SF36. We have evaluated the mission for the purpose of assessing planetary protection requirements. Based on the framework presented in *Evaluating the Biological Potential in Samples Returned from Planetary Satellites and Small Solar System Bodies: Framework for Decision Making* (NRC 1998), the Committee affirms that the target body belongs to class Ib. After discussion of this mission and the target body, the Committee recommends that no special containment for samples returned from 1998 SF36 is required for the purposes of planetary protection, provided that subsequent information obtained prior to sample return remain consistent with the classification of that body as an undifferentiated metamorphosed asteroid. As such, we recommend that for NASA purposes, the mission be designated Planetary Protection Category V, "unrestricted Earth return."**

Emerging Issues in Planetary Protection

Dr. Rummel highlighted some issues that may come before the Committee in the future. Europa is the most intriguing body in orbit around Jupiter. There is a contention that the ice cover could be thin in certain areas (chaos regions) with the potential for water coming to the surface. There is evidence of salt in the subsurface ocean with a potential for magnetism and similar environments to what can be found on Earth. Dr. Rummel reviewed the SSB recommendations on contamination of Europa. It recommended that Europa-bound spacecraft be cleaned, sterilized, and/or subject to radiation. A series of investigations should be conducted to reduce the uncertainty in calculating the probability of contaminating Europa. The SSB also developed recommendations for small body sample return. It recommended that all samples returned from planetary satellites and small solar system bodies that must be contained should be treated as potentially hazardous until proven otherwise. Dr. Rummel indicated that he would be ensuring that the international standards are representative of the best scientific opinion. The issue of how to get scientific advice needs to be addressed. The issue of human exploration will undoubtedly come before PPAC at some point in the future, probably within the next year or so. In response to a question, Dr. Rummel noted that NASA uses the COSPAR standards as the basis for NASA policy; however, NASA has developed policy in some areas that COSPAR hasn't addressed yet. Also, there is a lot to learn about Mars before there can be any decision regarding terraforming the planet.

The next meeting will be in the September/October timeframe. Dr. Noonan asked that members forward the names of any recommended or suggested Committee candidates to Dr. Rummel. Dr. Noonan requested that members provide input regarding any topics that should be addressed at the next meeting. She suggested that if there are areas or topics that require outside assistance or expertise, please inform her or Dr. Rummel well in advance of the meeting.

PLANETARY PROTECTION ADVISORY COMMITTEE
MIC-7, NASA Headquarters, Washington, DC

AGENDA
Day 1—18 March 2002

1:00pm	Welcome and Introductions	N. Noonan/J. Rummel
1:15am	Logistical Information	M. Norris
1:25pm	Charge to the Committee/Advisory Committee Structure	J. Rummel
1:45pm	Report from the NASA Advisory Council	N. Noonan
2:00pm	Introduction to Planetary Protection	J. Rummel
2:45pm	Break	
3:00pm	NASA's Solar System Exploration Program	C. Hartman
4:00pm	NASA's Mars Exploration Program	O. Figueroa
5:00pm	Adjourn	
6:00pm	Committee Dinner	701 Pennsylvania Avenue

Day 2—19 March 2002

8:30am	Planetary Protection Advisory Committee's Role in: —mission requirements/operations/extensions —interagency coordination —intergovernmental planning	Norine Noonan/ John Rummel
9:00am	Discussion with the Associate Administrator	Ed Weiler
10:00am	Introduction to Issues in Returned Sample Handling	Margaret Race
10:45am	Break	
11:00am	MUSES-C: NASA Participation and Asteroid Information	Donald Yeomans
12:00pm	Lunch	
1:00pm	MUSES-C Discussion	
2:00pm	Mars Planetary Protection: Issues and Status —Forward contamination —Backward contamination —Sample Handling Protocol	John Rummel
3:15pm	Break	

3:30pm	Emerging Issues in Planetary Protection —Europa and the Outer Planets —Human Exploration	John Rummel
4:30pm	Committee Discussion	
5:00pm	Adjourn	

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
March 2002

Individual Members:

Dr. Norine E. Noonan, Chair
NSSTC

Dr. John Rummel, Executive Secretary
NASA Headquarters

Dr. Ronald M. Atlas
University of Louisville

Dr. Colleen M. Cavanaugh
Harvard University

Dr. Carolyn S. Griner
Spacehab, Inc.

Dr. Debra L. Hunt
Duke University

Dr. John F. Kerridge

Mr. Alan Ladwig
Team Encounter

Dr. Debra G. B. Leonard
University of Pennsylvania

Dr. Eugene H. Levy
Rice University

Dr. Carle M. Pieters
Brown University

Dr. George S. Robinson, III
Robinson & Associates, Inc.

Dr. Diana Wall
Colorado State University

Dr. Lauie Zoloth
San Francisco State University

Representative Members:

Dr. Michael H. Carr
U.S. Geological Survey

Dr. Richard Orr
U.S. Department of Agriculture

Dr. Paul Gilman
U.S. Environmental Protection Agency

Dr. Robert A. Wharton
National Science Foundation

Dr. David Klein
NIAID, National Institutes of Health

International Representatives:

Dr. Michele Regimbald-Krnel
Space Science Program, Canadian Space Agency

Dr. Professor Akira Fujiwara
ISAS

Dr. Gerhard Schwehm
ESA/ESTEC

Dr. Michel Viso
CNES

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters, Washington, DC
March 18-19, 2002

MEETING ATTENDEES

Committee Members:

Noonan, Norine *(Chair)*	NSSTC
Atlas, Ronald	University of Louisville
Cavanaugh, Colleen	Harvard University
Hunt, Debra	Duke University
Kerridge, John	[not affiliated]
Ladwig, Alan	Team Encounter
Leonard, Debra	University of Pennsylvania
Levy, Eugene	Rice University
Pieters, Carle	Brown University
Robinson, George	Robinson & Associates
Rummel, John D. *(Executive Secretary)*	NASA Headquarters
Zoloth, Laurie	San Francisco State University

Representative Members:

Fujiwara, Akira *(Internat'l Representative)*	ISAS
Klein, David *(Agency Representative)*	NIH/NIAID
Orr, Richard *(Agency Representative)*	USDA
Schwehm, Gerhard *(Internat'l Representative)*	ESA
Viso, Michel *(Internat'l Representative)*	CNES
Wharton, Robert F. *(Agency Representative)*	NSF

NASA Attendees:

Dakon, Kathy	NASA Headquarters
Figueroa, Orlando	NASA Headquarters
Giza, Laura	NASA Headquarters
Hartman, Colleen	NASA Headquarters
Hoyt, Diana	NASA Headquarters
Norris, Marian	NASA Headquarters
Weiler, Ed	NASA Headquarters
Yeomans, Donald	NASA/JPL

Other Attendees:

Atloe, Ronald	University of Virginia
Billings, Linda	Spacehab, Inc.
Brandinger, Paul	Swales Aerospace
Burrowbridge, Don	Windermere
Cowing, Keith	NASA Watch
Garavelli, John	PSW
Kok, Aik Wan	[self]
Race, Margaret	SETI Institute
Shank, Chris	House Science Committee
Stabekis, Perry	Windermere

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters, Washington, DC
March 18-19, 2002

FINDINGS AND RECOMMENDATIONS

May 1, 2002

Dr. Edward Weiler
Associate Administrator for Space Science
National Aeronautics and Space Administration
400 E Street SW
Washington, DC 20546

Dear Dr. Weiler:

The inaugural meeting of the Planetary Protection Advisory Committee was held on March 18 and 19 of this year. Because this was the initial meeting, much of the agenda was devoted to introductory briefings and reports. However, we did consider at some length the MUSES-C mission. We were briefed by Dr. Donald Yeomans and from Dr. Akira Fujiwara on the technical details of the mission. The Committee discussed a number of issues and devised the following recommendation:

> **"The Committee heard presentations on the MUSES-C mission, and on the nature of the MUSES-C target body, 1998 SF36. We have evaluated the mission for the purpose of assessing planetary protection requirements. Based on the framework presented in *Evaluating the Biological Potential in Returned Samples from Planetary Satellites and Small Solar System Bodies: Framework for Decision Making* (National Research Council, 1998), the Committee affirms that the target body belongs to class Ib. After discussion of this mission and the target body, the Committee recommends that no special containment for samples returned from 1998 SF36 is required for the purposes of planetary protection, provided that subsequent information obtained prior to sample return remains consistent with the classification of that body as an undifferentiated metamorphosed asteroid. As such, we recommend that for NASA purposes, the mission be designated Planetary Protection Category V, "unrestricted Earth return."**

Should new information be obtained prior to sample return that would call into question this classification, the Committee would reconsider the matter at that time.

With regard to Mars, the Committee heard from Mr. Orlando Figueroa, Director for Mars Exploration on plans for Mars missions and Dr. John Rummel, NASA PPO, on the development of a protocol for Mars sample handling. The Committee will consider this Protocol in more detail at our next meeting.

The current membership of the Committee represents a good "mix" of backgrounds and expertise – however, there is still a need for expertise in risk analysis

and in science/risk communication. I am gratified that current members have already provided suggestions for candidates in these areas. I am especially pleased that most of the representatives from other Federal agencies have been appointed. Those that joined us at this first meeting provided useful information and thoughtful insights. I am also very pleased that we had excellent participation from the international representatives. The continued participation of the other agencies and our international partners will be critical for the future effectiveness of the Committee's deliberations. In addition, we are anxious for the Space Science Advisory Committee to name its liaison to the Committee so that we may carefully coordinate science objectives with planetary protection requirements as was envisioned when PPAC was established.

Much work lies ahead for our Committee. As NASA develops its roadmap and detailed plans for Mars exploration and for missions to other Solar System bodies, both forward and back contamination issues will loom large. To date, the scientific community has focused on the science objectives and design of a Mars sample return mission. Preparation for such a mission must also address planetary protection issues such as the need for a sample receiving/handling facility here on Earth, a "long-lead" item that will require extensive planning. The requirements for such a facility must be integrated with the science objectives before the detailed mission design has been finalized (and cost estimates developed). This has not been done to date and will, undoubtedly, be complicated by the relatively inefficient funding patterns inherent in the U.S. budget. Nevertheless, it seems prudent for the mission science definition team and NASA's Mars program managers to attend to this issue as soon as practicable – even in the face of significant uncertainty about the timing of a sample return mission.

The Committee heard from Dr. Colleen Hartman of the Solar System Exploration Division. Her presentation was a good reminder that while Mars represents the current focus of much of the planetary protection effort, future missions to other solar system bodies (e.g., Europa, small bodies) will likely raise planetary protection concerns for scientists, the public, and this Committee. The Committee looks forward to providing advice on a systematic and strategic approach to planetary protection issues across the entire gamut of Solar System Exploration activities. Such an approach might be especially helpful as both nearer- and farther-term missions are considered and take more definite shape.

On behalf of the entire Committee, I thank you for meeting with us. We appreciated your time and your perspectives both on science and on education and outreach activities. We also would like to thank all of our presenters. I offer a special thanks to Dr. Rummel, the Committee's Executive Secretary, and Ms. Marion Norris for their help in establishing this Committee and facilitating this meeting. Paula Frankel did her usual superb job as meeting rapporteur.

I know the Committee joins me in looking forward to working with you on the important planetary protection issues that will merit our attention as NASA pursues its Solar System exploration program.

Sincerely,

Norine E. Noonan, Ph.D.
Chairman

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters, Washington, DC
March 18-19, 2002

1) Charge: Planetary Protection Advsiory Committee [Rummel]
2) Introduction to Planetary Protection [Rummel]
3) Exploration of the Solar System [Hartman]
4) Following the Water: The Mars Exploration Program [Figueroa]
5) NASA Space Science – An Overview [Weiler]
6) Introduction to Issues in Returned Sample Handling [Race]
7) Current Status of MUSES-C Mission [Fujiwara]
8) MUSES-C Target Body Characterization [Yeomans]
9) Mars—Planetary Protection Issues and Status [Rummel]
10) Emerging Issues in Planetary Protection [Rummel]

Other materials distributed at the meeting:

1) Evaluating the Biological Potential in Returned Samples from Planetary Satellites and Small Solar System Bodies
2) Biological Contamination of Mars
3) Mars Sample Return: Issues and Recommendations
4) Preventing the Forward Contamination of Europa
5) The Quarantine and Certification of Martian Samples